



The action congruency effect on the feelings of agency



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ABSTRACT

Previous studies suggest that the sense of agency (SoA), the feeling of control about one's own actions and ensuing effects is also generated during action selection processes. We investigate whether the conflict at the action selection stage induced by a supraliminal stimulus, modulates an implicit measure of SoA, namely intentional binding. Furthermore, we were interested to investigate the influence of different types of stimulus-response compatibility on SoA. To this aim we compared the influence of an automatic imitation task and a stroop-like task on intentional binding. In both tasks participants performed congruent and incongruent fingers movements (key release) in response to an external stimulus. Their movements caused an effect and participants estimated the time between their action and the ensuing effect. We found a reduced intentional binding effect in incongruent compared to congruent conditions in both tasks. The results are discussed within the theoretical framework of the fluency of action.

1. Introduction

The experience that we are in control of our actions and their consequences is a fundamental aspect of our interaction with the environment. When playing piano, for example, we anticipate when pushing a key that a specific tone will follow. The experience of producing effects in the environment is known as sense of agency (SoA) (David, Newen, & Vogeley, 2008; Haggard & Tsakiris, 2009). Two measures of SoA have been distinguished (Synofzik, Vosgerau, & Newen, 2008): an explicit *judgment* of being the author of an action, i.e. “I am the cause of that effect”, and implicit measures characterized by the *feelings* of being the author of an action. One implicit measures of SoA is based on the perceived duration of intervals between the actions and the ensuing effects (Haggard, Clark, & Kalogeras, 2002). Since these intervals are perceived as compressed in time after voluntary actions, the effect is known as “*intentional binding*” and it is linked to a normal experience of SoA. Several studies suggest that the feelings of control over our actions and ensuing effects are due to predictive mechanisms: we experience a strong SoA when a match occurs between the predicted and perceived effect of our action (Blakemore & Frith, 2003; Blakemore, Frith, & Wolpert, 2001; Blakemore, Wolpert, & Frith, 2002; David et al., 2008; Moore & Haggard, 2008; Sato, 2009). In this vein, the SoA is considered to be retrospective, after the action is completed and we know its consequences (Farrer & Frith, 2002; Farrer et al., 2003, 2008). However, recent studies (for a review, see (Chambon, Sidarus, & Haggard, 2014) suggest that the SoA can be generated prospectively during action selection processes. This prospective component of agency has been investigated by using subliminal action priming (Chambon & Haggard, 2012; Chambon, Wenke,

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Fleming, Prinz, & Haggard, 2013; Wenke, Fleming, & Haggard, 2010). Specifically, participants had to respond to a target that was subliminally primed by a compatible or incompatible stimulus. Participants experienced stronger SoA when their action was compatible with the action prime. Furthermore, this effect was independent from the outcome's predictability (Wenke et al., 2010) and from poorer participants' performance (Chambon & Haggard, 2012). This stronger SoA in response to the prime-action compatibility has been explained by the *fluency* of action selection. That is, action selection processes become more fluent in response to the congruent subliminal prime which reduces the conflict between different action plans, and increases the SoA over action outcomes (Chambon & Haggard, 2012).

However, this interpretation is mainly based on unconscious priming. One aspect that has received less attention is whether the conflict at the action selection stage induced by a supraliminal stimulus, also affects the SoA. Nevertheless, a recent experiment by using supraliminal action primes (Sidarus & Haggard, 2016) revealed that when a conflict was present compromising the normal flow of the intentional action, the SoA over action outcomes was reduced. The authors conducted a supraliminal Eriksen-flanker task (Eriksen & Eriksen, 1974) in order to manipulate the congruency of action selection in response to a congruent or incongruent target. Participants' action caused a visual effect after a variable interval and at the end of each trial, they provided an agency rating.

Interestingly, they found that the conflict in action selection induced by the incongruent condition in the flanker task reduced the SoA over outcomes. This effect persisted also if the target-flanker SOA varied and when the participants were free to act congruently or incongruently with the stimuli (but see Damen, van Baaren, & Dijksterhuis, 2014). This study shows that response conflict that can be consciously perceived has an influence on explicit measures of SoA.

However, it is still an open question whether the perception of a supraliminal stimulus, which interferes with action selection, modulates implicit measure of SoA. In particular, no study has yet addressed the effect of classical response conflict induced by interference tasks on intentional binding. Therefore, our aim was to investigate the impact of stimulus-response conflict on implicit SoA by also comparing different types of stimulus-response compatibility. In fact, a second issue that has not been investigated so far relates to the question whether different types of stimulus-response compatibility have a differential influence on implicit SoA. It has been argued that there is a fundamental difference between conflict that is induced by overlearned responses such as reading in the Stroop task (where a dominant response has to be inhibited in support of an unusual response after a learned stimulus-response relationship), and conflict that is induced by an imitative relationship between the observed and planned action (Brass, Derrfuss, & von Cramon, 2005; Greenwald, 1972). Greenwald (1972) referred to the imitative relationship between the observed and executed action as to ideomotor compatibility. In an ideomotor compatible situation the observed stimulus strongly overlaps with the anticipated effect of the planned action and should therefore induce a strong response tendency (see also the dimensional overlap model by Kornblum, Hasbroucq, & Osman, 1990). Such a direct activation of an motor representation should have a stronger impact on agency, since the mere observation of others' actions activates a representation that is also used for motor planning (Brass, Bekkering, & Prinz, 2001).

To test these two hypotheses, we combined an ideomotor compatibility paradigm (Brass, Bekkering, Wohlschläger, & Prinz, 2000) and a Stroop-like paradigm with a time estimation procedure that investigates intentional binding effect (Engbert, Wohlschläger, Thomas, & Haggard, 2007; Kühn, Brass, & Haggard, 2013). In a first experiment we tested whether conflict induced by the so called imitation-inhibition paradigm leads to a reduction of intentional binding. Participants lifted their index or middle finger in response to a number, while simultaneously observing either congruent (i.e. the same) or incongruent (i.e. the opposite) finger movements of a mirrored right-hand. Their lifting movements caused an auditory effect after a variable interval. At the end of each trial, participants estimated the time between their action and the ensuing effect. To test whether imitative compared to overlearned responses have a stronger influence on intentional binding we also tested the influence of a Stroop-like task on the interval judgments in a second experiment. In this task, no finger movements were shown and participants performed congruent or incongruent finger lifting movements in response to a colored target. After their action, the same auditory effect was delivered and they performed the time estimation task. Furthermore, we conducted a third within-subject experiment, where the participants performed both tasks, in order to directly compare the intentional binding effect in these two paradigms.

We predict that congruent compared to incongruent trials should lead to strong intentional binding. Furthermore, based on the idea that ideomotor mappings should induce a stronger action tendency than overlearned mappings, we expect a stronger effect of congruency for ideomotor compared to overlearned mappings.

2. Material and methods

2.1. Experiment 1: Imitation-inhibition task and time estimation task

2.1.1. Participants

Twenty healthy volunteers (5 males, mean age: 18.8 years, SD: 1.4 years) were enrolled for the study. All participants were right-handed, as assessed by the Edinburgh Handedness Inventory (Oldfield, 1971). All testing procedures were approved by local ethical committee of Ghent University. All participants gave written informed consent and received academic credits for their participation.

2.1.2. Stimuli and procedure

Subjects were seated at a distance of 60 cm from the computer monitor (refresh rate 60 Hz, using a monitor of 53 × 30 cm with a resolution of 1920 × 1080). Experimental stimuli consisted of a sequence of images (300 × 200 pixels) of a mirrored right-hand of an actor performed lifting finger movements. The first image showing the hand in resting position for 566.67 ms and then followed two images lasting 16.67 ms in which the finger lifting movements (index or middle finger) and a number (1 or 2 that appeared

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